# An Ottoman Astrolabe Full of Surprises

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**Abstract** Recently a set of plates from an 11th-century Andalusi astrolabe has been discovered inside an Ottoman Turkish astrolabe from ca. 1700. Most of these plates conform to the tradition represented by some fourteen surviving Andalusi astrolabes from the 11th century. One of the plates, however, serves the latitude 16;30° south of the Equator, and this feature, not attested on any known astrolabe (Byzantine, Islamic or European), raises a number of intriguing questions.

## Introduction

In 1987, Len Berggren's contribution to the *Festschrift* for Asger Aaboe was a paper entitled "Archimedes among the Ottomans" [Berggren 1987]. In this, he described Archimedean materials that he had discovered in a text by a 17th-century Ottoman scholar named al-Yanyawī (from the town that is now Ioannina or Jannena in Northern Greece). More recently, Ekmeleddin İhsanoğlu and his colleagues in Istanbul have published multiple volumes of bio-bibliographical materials on hundreds of scientists in the Ottoman world.[1]

There can be no doubt that Ottoman manuscript sources, not least when they contain earlier material that would otherwise be lost, have much to contribute to the history of Islamic science. In this paper I present an Ottoman 'document' of a different kind that merits our attention.

The astrolabe shown in Figure 1 was auctioned at Sotheby's in London in 1991 and passed into a private collection in Europe [Sotheby's 30.05.1991, 136 (lot no. 391)].[2] It is now in the Museum of Islamic Art in Doha. It is unsigned and undated, and it has been assigned the number #4040 in the International Instrument Checklist.[3] The front and the back are clearly Ottoman, doubtless made in Istanbul and probably from around 1700.[4] The rete was made by the same person, but shows Andalusi influence (see below).

Ottoman astrolabes are characterized by their relative simplicity.[5] A minimum of decoration and astronomical and trigonometric scales and diagrams, first encountered in earlier astrolabe traditions — Abbasid Iraqi and Iranian; early Andalusi;[6] later Iranian; later Andalusi and Maghribi; Mamluk Syrian

[1] See İhsanoğlu *et al.* [1997–2000], for the volumes relating to astronomy, mathematics and geography.

[2] The components are listed in King [2005, 1006 (1.3.11a), 1013 (2.3.10a)]. See also King [2005, 944–945, 956 (plates)].

[3] On this convention see King [2005, 360].

[4] Some of the productions of the Istanbul astrolabists Ibrāhīm ibn Muḥammad al-Balawī and Aḥmad Ayyūbī around 1700 include new components for older astrolabes [King 2005, 1013, nos. 2.3.5–6]. I have not been able to show that either of these men made the later additions in the astrolabe under study.

[5] See King [2005, 1013–1014], for a list of some of these, and King [2005, 774–796], for detailed descriptions of the earliest two examples.

[6] I use the convention of Prof. Julio Samsó of Barcelona and his colleagues that al-Andalus refers to that part of the

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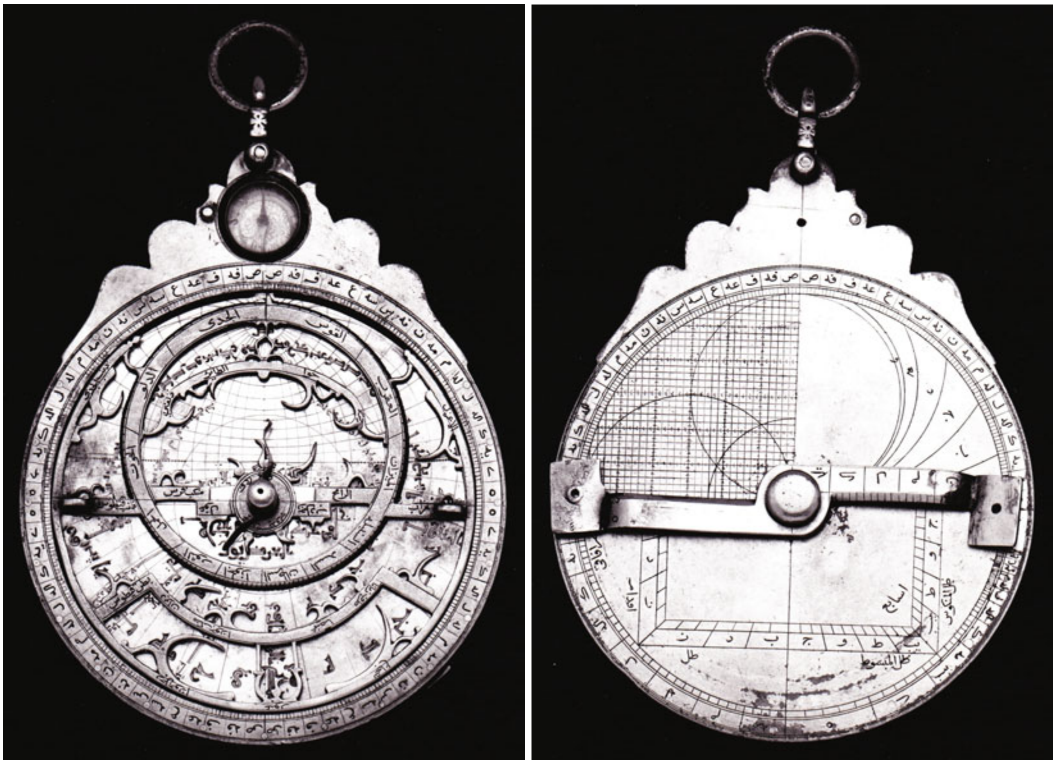

Figure 1: The front and back of the unsigned, undated Ottoman astrolabe. Photo courtesy of the former owner.

and Egyptian — are attested on Ottoman pieces. The inscriptions are in a mixture of Arabic and Arabic with Persian influence, and they are in *naskhī* script.

For me, the first surprise came in the early 1990s when I opened the Ottoman astrolabe to look at the plates; these were a set of seven plates from an 11th-century Andalusi astrolabe. Some 14 astrolabes survive from that milieu, though none earlier and, curiously, not one from the 12th century, although we do have some from the 13th century.[7] Two plates are shown in Figs. 3–4.

What has happened here is that our Ottoman astrolabist came into possession of this set of Andalusi plates and found them so imposing that he constructed a new mater to house them and a new rete to use with them. He even extended the range of latitudes represented with three new sets of markings. Perhaps, when he acquired the Andalusi plates, there was an original mater to house them, but this has not survived. Neither has the original rete, on which the star-positions would have been some 600 years out of date by his time.

One of the plates, in particular, attracted my attention, for it is unlike any other known plate, and it is this that occasioned the present study. The Ottoman mater and rete are of interest in their own right and so we look at the entire instrument in some detail.

Iberian peninsula under Muslim domination at a given time. Thus, the term does not relate to the medieval equivalent of the modern province of Andalucía.

[7] For a list, see King [2005, 1006]. Detailed descriptions of all of them have been prepared, and I hope to publish these eventually.

## Some Preliminaries

Astrolabe plates from early Iraq and Iran (roughly, 800–1100) usually serve a series of latitudes appropriate for the Eastern realms: 33° (Baghdad), 36° (Rayy), and sometimes 21° (Mecca) and 24° (Medina) [King 2005, 439–544, 948–950]. Usually the length of longest daylight will be stated for those latitudes, invariably using the Ptolemaic value for the obliquity of the ecliptic, 23;51°. This tradition derives from the earliest Greek and earliest Islamic astrolabes (8th century) that had plates for each of the seven climates of Antiquity which are defined in terms of the length of longest daylight at those latitudes (see Figure 2) [King 2005, 421, 428–429, 948]. The idea was to produce instruments that were universal, serving all regions of the earth.

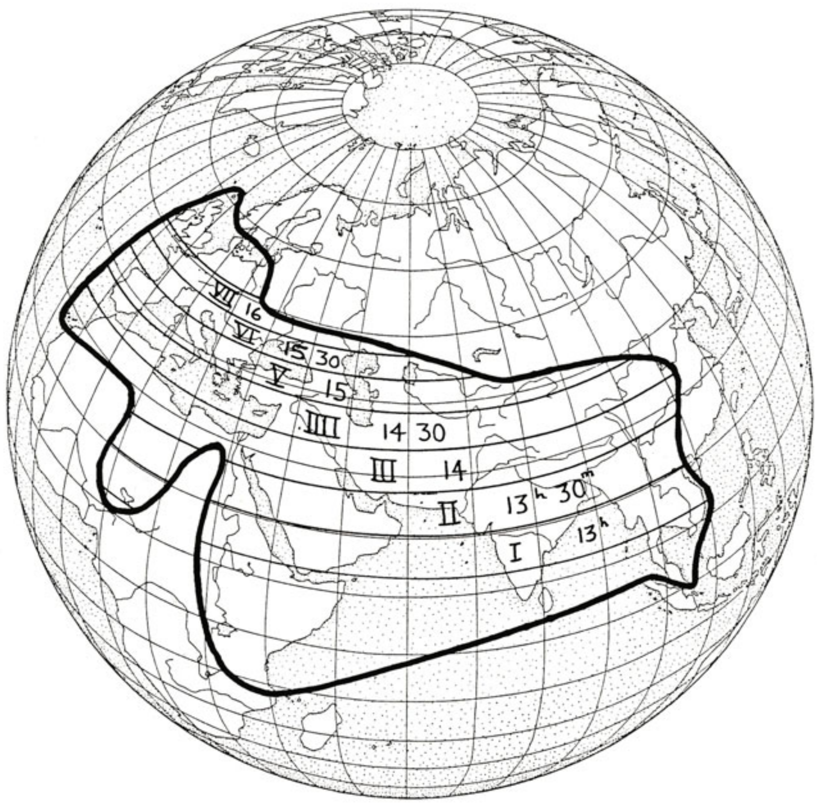


Figure 2: The seven climates of Antiquity with the world known to Ptolemy [King 2004, 689].

The earliest known Andalusi astrolabe, from the 10th century and surviving only in an illustration, has plates for the climates [King 2005, 383 928]. All 11th-century Andalusi astrolabes have plates for a wider range of latitudes than their Abbasid predecessors, usually with the associated length of half daylight and usually also with a series of names of localities mainly but not always in the Islamic West [King 2005, 951–957].

Figure 3: The plate for 32°. Photo courtesy of the former owner.

## The First Surprise: The Andalusi Plates

One of the plates is shown in Figure 3. The inscriptions are in an elegant but heavy Andalusi *kūfī* script. A peculiarity, which could serve to identify the maker, is the 6 and 7 in the two sets of numbers for the seasonal hours: they are sometimes written as one or the other of each of "S" and a backwards "S." Alas, I have not been able to identify the maker by comparison with the engraving on other astrolabes from the same milieu (or with the localities chosen for the latitudes or with the unusual division of the azimuth curves — see below). The astronomical markings are all competently executed. Given what we know about 11th-century Andalusi astrolabes, it is not surprising that the main set of plates that we find inside the Ottoman astrolabe has markings for a wide range of latitudes and localities (this time without daylight lengths):

| | |
|---|---|
| 23° | Mecca, Jedda, Taif, Yamama, Ṣiraf, al-Manṣūra in China (!) |
| 25° | Yathrib (= Medina), Hajar, Bahrein |
| 30° | Miṣr (= Cairo-Fustat), Kirman, Siniz (near Ahwaz), ʿAyn Shams (= Heliopolis) |
| 32° | Kairouan, Tiberias, Ascalon, Alexandria |
| 33° | Baghdad, Hit, Damascus, Tunis (!), Salé |
| 35° | Ceuta, Tangiers, Sicily, Mosul, Manbij, Qum |
| 36° | Almería, Harran, Samarqand, Raʾs al-ʿAyn |
| 37;30° | Seville, Málaga, Granada, Bukhara, Rayy |
| 38;30° | Cordova, Murcia (written *m-r-s-y-l-h* !), Marwarrūdh, Balkh, Jurjan |
| 45° | Constantinople, Burjān (??) |

There are altitude circles for each 6° and azimuth circles for each 9°, as well as curves for the times of the prayers: the *ẓuhr* shortly after midday and the beginning and end of the *ʿaṣr* in the afternoon (*waqt ṣalāt al-ẓuhr*, *waqt ṣalāt al-ʿaṣr*, and *waqt ākhir al-ʿaṣr* or *ākhir waqt al-ʿaṣr*), as well as special markings for twilight at 18° above the horizon (*al-fajr*, daybreak, on the left, and *al-shafaq*, nightfall, on the right).[8] These are standard on Andalusi and Maghribi astrolabes.

Unusual is the marking of the azimuth circles *for each 9°*; this is attested only on two other 11th-century Andalusi astrolabes (#118, made by Ibrāhīm ibn Saʿīd al-Sahlī in Toledo in 460 H [= 1067/68], preserved in Oxford [Gunther 1932, vol. 1, 253–256]; and #1099, made by Aḥmad ibn Muḥammad al-Naqqāsh in Saragossa in 472 H [= 1079/80], preserved in Nuremberg [King 1992, vol. 2, 568–570]; see also below). This raises the question whether the altitude and azimuth circles were engraved using geometrical construction or using tables of polar coordinates, such as were compiled by al-Farghānī in Baghdad in the mid 9th century (although no manuscripts of his work on astrolabe construction are known from the Islamic West). With such tables, polar coordinates of the centres of the various circles with respect to the centre of the astrolabe are given for each degree of altitude and each degree of azimuth for each degree of latitude.[9] In any case, as we shall see, our Ottoman astrolabist was clearly quite taken by the idea of drawing the azimuth circles for each 9°.

Here there are more Eastern Islamic localities than is usual on early Andalusi plates, even though there are some astrolabes that give even more information.[10] Amongst the other pieces that have similar lists of localities are #118 and #1099, mentioned above. Frankly, such information is an *excès de délicatesse*; most of the places in the Islamic East would be unknown to the average Andalusi.

It is worth comment that medieval latitudes do not always reflect actual values. Here we find 23° used for Mecca, which is some 1½° too high. Alas, we do not find this value on any other contemporaneous astrolabe. (Muslim astronomers in the 9th century measured the latitude of Mecca as 21°, 21;30° and 21;40°.)[11]

Another good example is the 45° used for Constantinople, also not found in other contemporaneous astrolabes. This value, some 4° too high, is even attested in Byzantine sources, and results from putting the Rome of the East at the middle of the 6th climate rather than the middle of the 5th, where it belongs.[12] What is curious is that our Ottoman astrolabist did not see fit to delete the name Constantinople or to make a new set of markings for latitude 41°.

Notice also the error in the latitude of Tunis; this suggests that the maker was far from Tunis (that is, in al-Andalus and not in al-Maghrib). However, the same error is made on other 11th-century Andalusi astrolabes.

I suspect that at least one plate of markings for, say, latitudes 41° and 42°, is missing from the set. But it baffles me why our Ottoman astronomer would have dumped a plate that would have served Istanbul (and also why he did not prepare such a plate himself; see below).

Additional markings for the astrological houses and the casting of the rays (*taswiyat al-buyūt wa-maṭraḥ al-shuʿāʿ*)[13] for latitude 35° (see Figure 4) suggest at first sight that this latitude was favored by the maker, indeed either that this was the latitude of the locality where he made the astrolabe or of the destination for which the instrument was intended. Only the towns of Ceuta and Tangiers could come into consideration here, in spite of the fact that an Andalusi rather than Maghribi provenance for the plates is almost certain. We note that under the Ḥammūdids in the first part of the 11th century

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[8] On such markings, see King [2005, 46–50]. They are to be used with the point of the ecliptic opposite to the position of the sun.

[9] See Lorch [2005, 111–293], for the tables, and King [2005, 39–41], for the context.

[10] On the coordinates of localities in the written sources see Kennedy and Kennedy [1987]. For latitudes displayed on early Eastern and Western Islamic astrolabes (to ca. 1100), as well as the earliest European astrolabes, see King [2005, 915–962].

[11] King [2012, 225–228 (paper IX)], on early measurements of the latitude of Mecca.

[12] See King [1991] on this pathetic state of affairs.

[13] For references to the rich literature on this subject see Casulleras [2004]. The article "Tasyīr" by O. Schirmer in $EI_2$ is still useful.

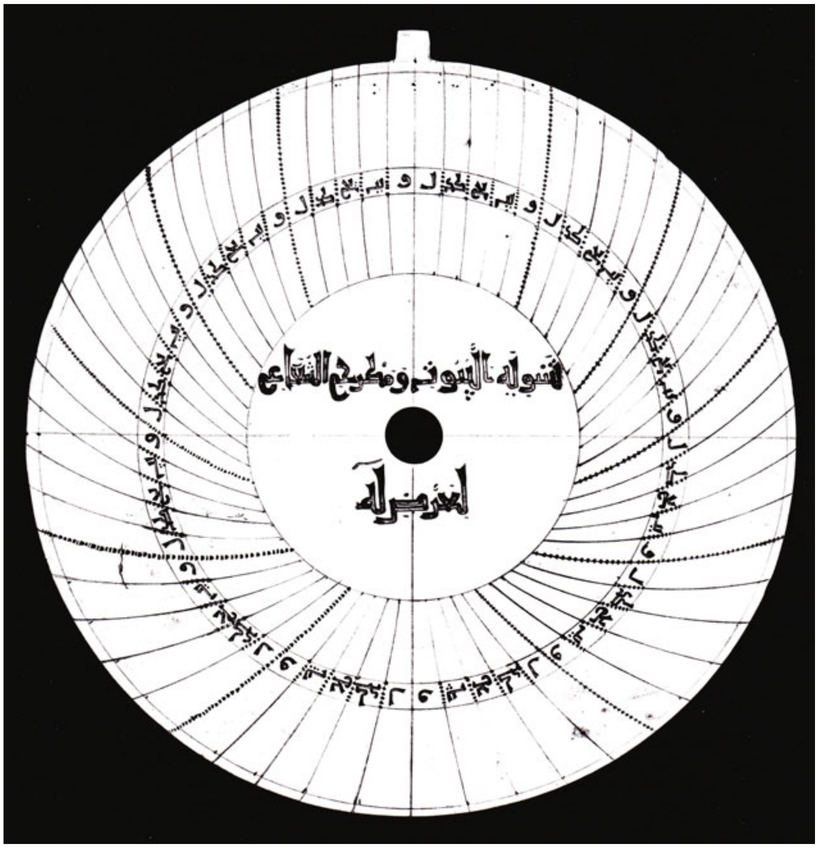

Figure 4: The astrological plate for latitude 35°. Photo courtesy of the former owner.

Ceuta, Tangiers, were united with Algeciras and Málaga in a single principality.[14]

Perhaps there was originally an additional plate with markings on both sides for the astrological houses for other latitudes, and our Ottoman astrolabist thought he could dispense with this. Such markings for latitudes further north in al-Andalus do occur on various three other 11th-century Andalusi astrolabes. The earliest attestation of such markings is on the spectacular astrolabe of al-Khujandī in Baghdad dated 984/5 [King [2005, 368, 508 (fig. 9f), 514].

There is also a set of markings for the horizons of 17 latitudes (Figure 5):

18° - 30° - 37° - 45° - 60° - 73° / 22° - 33° - 40° - 63° /
25° - 32° - 36° / 28° - 35° - 38° - 66°

This selection ensures that every few degrees are represented. The half horizon for latitude 66° is an arc of the circle of the ecliptic, but before we jump to any conclusions, we should look at the four radial declination scales, divided for each 6° and subdivided for each 1°. Noteworthy is the obliquity of the ecliptic engraved at the ends of each of these scales: it is 23;33°, a value associated with the observations conducted in Baghdad for the Caliph al-Maʾmūn in the early 9th century. This kind of markings for the horizons is associated with the 9th-century Baghdad astronomer Ḥabash al-Ḥāsib and is not attested on any of the other known 11th-century Andalusi astrolabes. Again, the first attestation of such markings is on the astrolabe of al-Khujandī [King 2005, 367, 509 (fig. 9g), 514].

The following is the arrangement of the markings on the fronts and backs (a/b) of the seven original plates:

1a: surprise coming up – 1b: houses for 35°

[14] See the articles "Sabta," "Ṭandja," and "Ḥammūdids" in $EI_2$.

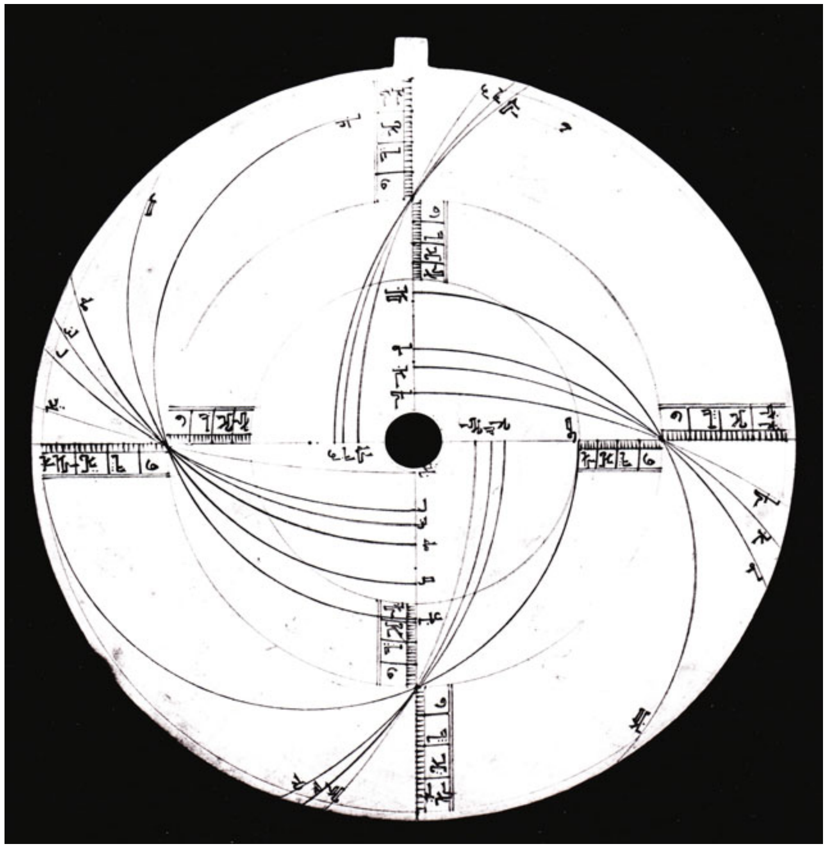

Figure 5: The plate of horizons. Photo courtesy of the former owner.

2a: 23° – 2b: 25°  3a: 30° – 3b: 32°
4a: 33° – 4b: 36°  5a: 35° – 5b: horizons
6a: 37;30° – 6b: 38;30°  7a: 45° – 7b: originally blank

## The Biggest Surprise of All

There is a plate for 16;30° *South* (Figure 6).[15] This is labelled *khalf khaṭṭ al-istiwāʾ fī l-janūb*, literally "behind the equator in the South." The horizon is now concave downwards, whereas for northern latitudes it is concave upwards. The curve for altitude 18° is almost a straight line. The additional markings are the same as on the other plates, even as far as the prayers are concerned! It should nevertheless be understood that the presence of this plate is purely symbolic.

No other Islamic astrolabic plates for southern latitudes have survived from before the Moghul period in India (16th–17th century); from that milieu we even have two double astrolabes, each with two retes for the northern and southern skies and each plate with a northern astrolabic projection on one side and a southern one on the other.[16] The existence of this particular plate shows first of all that

[15] The importance of these markings is already signaled in King [2005, 944–945].

[16] Turner [1985, 74–83] and Pingree [2009, 82–87] feature the one formerly in the Time Museum, Rockford IL, and now in the Adler Museum in Chicago, in considerable detail. A second one by the same maker surfaced in 2011 in a private collection.

Figure 6: The plate for latitude 16;30° South. Photo courtesy of the former owner.

an Andalusi astrolabist in the 11th century would not shy away from constructing a plate for a southern latitude.

Already in the 9th and 10th centuries Muslim astronomers had developed mixed retes with parts of the ecliptic based on northern projections and others based on southern ones. The plates on these instruments were correspondingly complicated; alas, no instruments of this kind survive.[17]

The latitude 16;30° South is that of Anti-Meroë, corresponding to the middle of the first climate in the southern hemisphere with a length of longest day of 13 hours. It is the lower limit of the *oekumene* in the three cartographic grids associated with Ptolemy of Alexandria [Neugebauer 1969, 220–224; Neugebauer 1985, 934–940; Berggren and Jones 2000, 35–41]. Was our Andalusi astrolabist influenced by a tradition imported from the Islamic East, essentially Baghdad, or did he think of this himself or take the idea from some other Andalusi?

Now the upper limit of Ptolemy's world, the limit of the ocean surrounding the earth, was sometimes taken as 72°±1°. Notice this latitude (73°) is represented on the Andalusi plate of horizons. It is doubtless significant that two 11th-century Andalusi astrolabes — #116, made by Muḥammad ibn al-

[17] On mixed astrolabes see King [2005, 55–57, 376, 557–563].

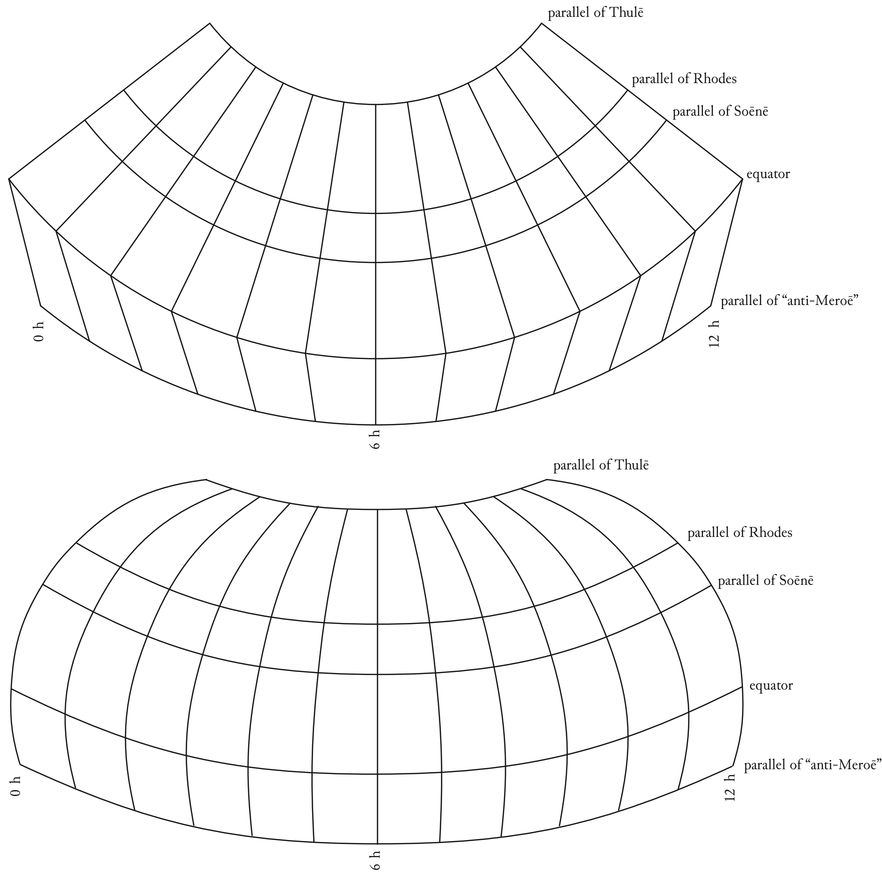


Figure 7: The extent of Ptolemy's first and second cartographical representations from 16½° South to 72° North. Graphics due to A. Jones.

Sahlī in Toledo in 420 H [= 1029/30], now in Berlin,[18] and #121, made by Ibrāhīm al-Sahlī in Valencia in 478 [= 1086], preserved in Kassel,[19] have a plate for latitude 72° [King 2005, 943–944]. These plates for 72° only make sense when one realizes that both of these astrolabes, as well as serving numerous latitudes, are also fitted with markings for latitude 0°; in other words, in a sense, they serve the whole world.

The plate for 16;30° South certainly makes no sense in relative isolation. I hypothesize that there must have been a plate for 72° as well, in which case the maker could have claimed that he had made an astrolabe for the whole of the known world. This would then be unique in the history of instrumentation. We know already of astrolabes with sets of plates for each of the seven climates or for a series of latitudes from 0° to 90°; here then we would be witness to an interesting twist at being universalistic.

One may wonder whether the European tradition of representing southern astrolabic projections on the face of clocks was inspired by Western Islamic practice. In this regard, we note that a geared astrolabe from northern France datable to ca. 1300 is based on a southern stereographic projection [Gunther 1932, vol. 1, 347, pls. LXXX and LXXXI (no. 198)].[20]

[18] See Woepcke [1858], for a detailed description of this piece, summarized by Gunther [1932, vol. 1, 251–252],

[19] See Gunther [1932, vol. 1, 263] and Schmidl [2007] for a summary of a detailed description prepared by the same author.

[20] Another more sophisticated device of this kind, dating from the same milieu, has recently come to light in a private collection.

The value 16;30° for the latitude of the middle of the first climate tells us something more, because for obliquity 23;33°, which our Andalusi astrolabist favored, it should be 16;40°. In fact, 16;30° corresponds more closely to Ptolemy's obliquity 23;51° (accurately the latitude is 16;27°, although Ptolemy himself used 16;25°). Ptolemy's obliquity was used, implicitly if not explicitly, on all known Islamic astrolabes, Eastern and Western, up to ca. 1100, with one exception.[21]

## The Ottoman Additions

The Ottoman components are engraved in a plain and elegant *naskhī* script typical of the milieu from which they hail.

We note that there is a magnetic compass on the front of the throne, with no indication of the existence of magnetic declination. Already ca. 1300 various Islamic instruments were fitted with a compass [Schmidl 1997–1998], though not usually astrolabes, where they are superfluous anyway. Indeed, compasses are rarely found on late Islamic astrolabes. (They are also very rarely found on European astrolabes after ca. 1450.) On this particular compass there is no indication that the compass may not point due north. (In the Islamic world, magnetic declination was first measured by al-Wafāʾī in Cairo ca. 1450 but not widely discussed thereafter.)

On the front rim there are four altitude scales labelled for each 5° up to 90° and subdivided for each 1°.

On the back of the mater, we find precisely the standard markings that identify this piece as Ottoman. On the upper rim, there are two altitude scales for each degree, labelled for each 6°. In the upper left, there is a sine quadrant with equi-spaced horizontal and vertical lines for each 2 units. There is a declination quadrant of radius 24 and two axial semicircles for calculations of sines and cosines. On the upper right there is a universal horary quadrant with markings for each seasonal hour 1–6. The shadow squares below the horizontal diameter serve bases 7 on the left (*al-aqdām*) and 12 on the right (*al-aṣābiʿ*). These serve to find tangents on the horizontal scale (*ẓill al-mankūs*) and cotangents on the vertical ones (*ẓill al-mabsūṭ*). The circumferential scale on the lower left serves to find the altitude of the sun at the afternoon prayer (*ʿaṣr*) from the meridian altitude of the sun, and since this works for all latitudes it is labelled *āfāqī*, universal, literally, serving all horizons. The corresponding scale on the lower right serves the cotangent to base 12. Our astrolabist has misspelled the word for "digits" as *asābiʿ* when it should be *aṣābiʿ*; only a non-Arabic speaker would make such a mistake. The word *asābiʿ* does have a meaning in Arabic, namely, "seventh fractional parts." The same error occurs on another Ottoman astrolabe #4112, formerly preserved in Kandilli Observatory near Istanbul and now apparently in the Rehmi Koç Museum in that city, which appears to be by the same anonymous maker [Dizer 1986, 13 (no. 12, illustrations of the front and back)].

The rete is elegantly executed (see Figure 8). The style is not original but is inspired by an astrolabe of the Andalusi astronomer Ibn Bāṣo who worked in Granada ca. 1300. The most significant aspect of this design is the equatorial bar in the upper ecliptic. One of the three known astrolabes of Ibn Bāṣo — #144, dated 704 Hijra [= 1304/05], present location unknown, has Ottoman additions (see Figure 9) [Gunther 1932, vol. 1, 289 (confused); *Linton Catalogue*, 1980, 87–89 (no. 162)]. Maybe it was precisely this piece that our Ottoman had seen. Even the star-pointers on the Ottoman piece are influenced by those on Ibn Bāṣo's rete. (The other astrolabe by the same maker, #4112, has a standard Ottoman rete.)

The scale for the ecliptic is divided for the 12 signs of the zodiac, subdivided into 3° intervals. The name *al-asad* for Leo has been incorrectly engraved on the ecliptic ring as *a-l-s-d*. (Spelling mistakes on Islamic astrolabes are very rare.) The following 25 stars are named on their pointers, with one other unnamed, reading counter-clockwise from the vernal equinox on the left:

*baṭn qayṭūs – ghūl – dabarān – ʿayyūq – rijl-i jawzā – mankib-i jawzā // ʿabūr – ghumayṣā –* [*yad-i dubb*], written

[21] Inevitably al-Khujandī's spectacular astrolabe from Baghdad, 984/85. See King [2005, 513–517].

Figure 8: The Ottoman rete. Photo courtesy of the former owner.

*y-d-w-b – ṭaraf-i zubānā – shujāʿ – rijl-i dubb* – unnamed // *al-ghurāb – al-aʿzal – al-rāmiḥ – fakka – ḥayya – ḥawwā* // *wāqiʿ – al-ṭāʾir* (with a *hamza*!) – *ridf – dulfīn – dhanab al-jady – mankib-i faras – dhanab-i qayṭūs*

For identifications the reader should consult the list of astrolabe stars compiled by Paul Kunitzsch [Kunitzsch 1966, 59–69; Kunitzsch 1990]. Significant here is the use of the *Western Arabic* names of the stars Sirius and Procyon (α Canis maioris and α Canis minoris), namely, *ʿabūr* and *ghumayṣāʾ*. These are generally found *only* on Western Islamic astrolabes; on Eastern ones, which include Ottoman pieces, the standard names are the *Eastern Arabic* ones *al-shiʿrā al-yamāniya* and *al-shiʿrā al-shaʾamiya*. What has happened here is that our Ottoman astrolabist has copied these names from a Western Islamic rete, either the one that might have been on the original Andalusi astrolabe, or another, an astrolabe in the tradition of Ibn Bāṣo, with 28 pointers for a similar set of stars, that might have been available to him in Istanbul (#144, see above). I have not investigated the star-positions on these two astrolabes, though this would be worthwhile. On the other Ottoman instrument that may have been by the same maker (#4112, see above), two different names are given for Sirius: *ʿabūr* and *shiʿra-yi yamānī*; for Procyon we find *ghumayṣā* again.

We now turn to the three sets of latitude dependent markings that our Ottoman astrolabist included himself, two on a new plate. These serve the following latitudes, and the associated lengths of maximum daylight are accurately calculated for obliquity 23;35°:

8a: 27° – 13;43$^{h}$ ;  7b: 43° – 15;12$^{h}$ ;  8b: 48° – 15;52$^{h}$.

These latitudes complement those on the Andalusi plates, showing that our Ottoman astrolabist intended to render his new instrument serviceable and not simply aesthetic. The latitude 27° could serve Akhmim in Egypt and Qulzum on the Red Sea littoral. Latitude 43° would have served, say,

Figure 9: An example of the retes of Ibn Bāṣo. Photo courtesy of the former owner, and also used in Linton Catalogue [1980, 89].

Skopje and Sarajevo, but we can only speculate about his intentions with latitude 48°, close to the middle of the 7th climate, perhaps intended for Buda and Pest. On the other astrolabe by the same maker (#4112, see above) the latitudes served are

21;30° 24° 30° 32° 33;30° 36° 38° 39° 40° 41° 42° 43° 45°.

Our Ottoman astrolabist made no comment on the Andalusi plate for 45°, marked for Constantinople. He would have known perfectly well that the latitude of Istanbul was 41° or thereabouts, but for some reason he did not include a new plate for that latitude. This is curious indeed, since he went to the trouble of making new markings for 43° and 48°.

On the new markings altitude circles are engraved for each 6°, which is standard, and azimuth circles *for each 9°*, the only documented example apart from the Andalusi astrolabes mentioned above (common divisions are 6° or 10°). Clearly, our Ottoman astrolabist was, with good reason, fascinated by the Andalusi plates. He also drew special curves on each set of markings for the first and second afternoon prayers (*ʿaṣr-i awwal* and *ʿaṣr-i thānī*), and marked with fish-bones the altitude 18° above the horizon which serves for the determination of daybreak and nightfall.

The alidade is marked on one fiducial side with a scale divided for each 10 units subdivided for each 2 units. The sighting vanes have been flattened so that they are no longer serviceable. The pin seems to be by our Ottoman astrolabist, but the "horse" is missing.

## Conclusions

My contribution to Asger Aaboe's *Festschrift* was a paper entitled "Universal solutions in Islamic astronomy," and in this I surveyed the numerous tables and instruments prepared by Muslim astronomers that served all terrestrial latitudes [Berggren and Goldstein, eds. 1987, 121–132; King 2004 (reprint), 679–709]. We may now perhaps add another example, two aspects of which were known already, namely, the preparation of astrolabe plates:

1. for each of the seven climates (on the earliest Eastern astrolabes and on the earliest Western astrolabes);
2. for latitudes between 0° and 90° (well attested over the centuries);

and now there is a possible third aspect (partly hypothetical):

3. for latitudes between the lower and upper limits of the Ptolemaic cartographic tradition (suspected on this one incomplete 11$^{th}$-century Andalusi astrolabe).

I have argued elsewhere for medieval astronomical instruments to be treated with the same kind of respect as medieval manuscripts. They too are historical 'documents,' and of particular interest are pieces that display two or more layers of components or inscriptions [King 2011, study I (published 1994); King 2005, studies X and XIIIa]. May this one please Len, who has rediscovered medieval Islamic sundials and published several papers on them. Perhaps I can now persuade him in his retirement to have a look at some medieval Islamic astrolabes or related devices in between fishing trips. He will not have to look at many before he discovers some features that will take him by surprise.

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